Wilson Bull., 108(2), 1996, pp. 369–371

SHORT COMMUNICATIONS

Avoidance of cabbage fields by Snow Geese.—Available evidence suggests that herbivores generally avoid sulfurous odors and volatile fatty acids (Mason et al. 1994) because such odors are associated with carnivore urine and feces (Nolte et al. 1994). Alternatively, or in addition, herbivores may avoid sulfur volatiles because they signal the bioaccumulation of toxicants such as selenium (Morris 1970) or because they indicate the presence of microbial degradation products that are toxic to vertebrates (Guildford et al. 1987).

Greylag Geese (*Anser anser*) avoid skatol (Neuhaus 1963), a (albeit nitrogenous) volatile present in the feces of predatory civet cats (*Civettictis civetta*) and in the fruits of some plants. Contrary to prevailing belief, the olfactory performance of birds in general is on a par with that of mammals (Clark and Mason 1989). Anecdotes provided by farmers suggest that geese rarely forage on winter cover crops in fields where cabbage had been planted the previous summer. A variety of sulfurous volatiles result from the decomposition of cabbage (*Brassica oleracea capitata*), including hydrogen sulfide, methyl disulfide, dimethyl disulfide, and various methyl mercaptans (Dateo et al. 1957, Self et al. 1963). We patterned the present series of observations to test the hypothesis that the odors of decaying cabbage repel Snow Geese (*Chen caerulescens*). We chose Snow Geese as our model species for three reasons. First, this bird is a strict herbivore. Second, large numbers of Snow Geese overwinter in southern New Jersey, our study area. They routinely forage on the winter cover crops planted in fields (Mason and Clark 1994). Thus it was possible to obtain a large number of fields in which cabbage had been planted the previous summer, and within which geese could possibly feed. Third, Domestic Geese (*Anser anser*) respond to plant odors (Neuhaus 1963, Wurdinger 1979), and captive Snow Geese will avoid high concentrations of Deer Away Big Game Repellent (IntAgra, Minneapolis, Minn.) (Mason, unpubl. obs.). The repellency of this commercially available product depends upon the production of sulfur odors and volatile fatty acids (Bullard et al. 1978).

Study area and methods.—We selected 16 fields near Cedarville, New Jersey, for study. All were physically similar (30–40 ha in size, adjacent to other agricultural fields on at least 3 sides) and within 5 km of Delaware Bay marsh habitat used by ≥30,000 overwintering Snow Geese (L. Widjeskog, N. J. Div. Fish and Game, pers. commun.).

Cabbage had been planted in eight of the fields during the 1994 growing season. Peppers (*Capsicum frutescens*, N = 6) or soybeans (*Glycine max*, N = 2) had been planted in the other eight fields. Conversations with farmers indicated that cabbage, peppers, and soybeans were rotated among all of the fields in multiyear cycles. During the observation period, all of the fields were planted with rye (*Secale cereale*). The maturity of the rye in all 16 fields was similar.

We paired cabbage and control fields on the basis of proximity; no member of any pair was more than 200 m apart. At the middle of each field, we established a 100-m transect parallel to the longest axis of the field and marked the ends of each transect with 0.4 m long wooden survey stakes.

Between 30 October 1994 and 20 March 1995, we visited all fields at seven-day intervals. During each visit, we walked each transect and collected all goose droppings with 0.5 m of the transect midline. We took the droppings to the laboratory and dried them in an oven at 37°C to a constant mass or for 72 h. We used these masses as an indication of goose activity (Mason et al. 1993, Mason and Clark 1994). We did not attempt to analyze the cover crop or the soil for the presence of sulfurous compounds, although sulfurous odors were readily apparent to us during our visits to cabbage fields.

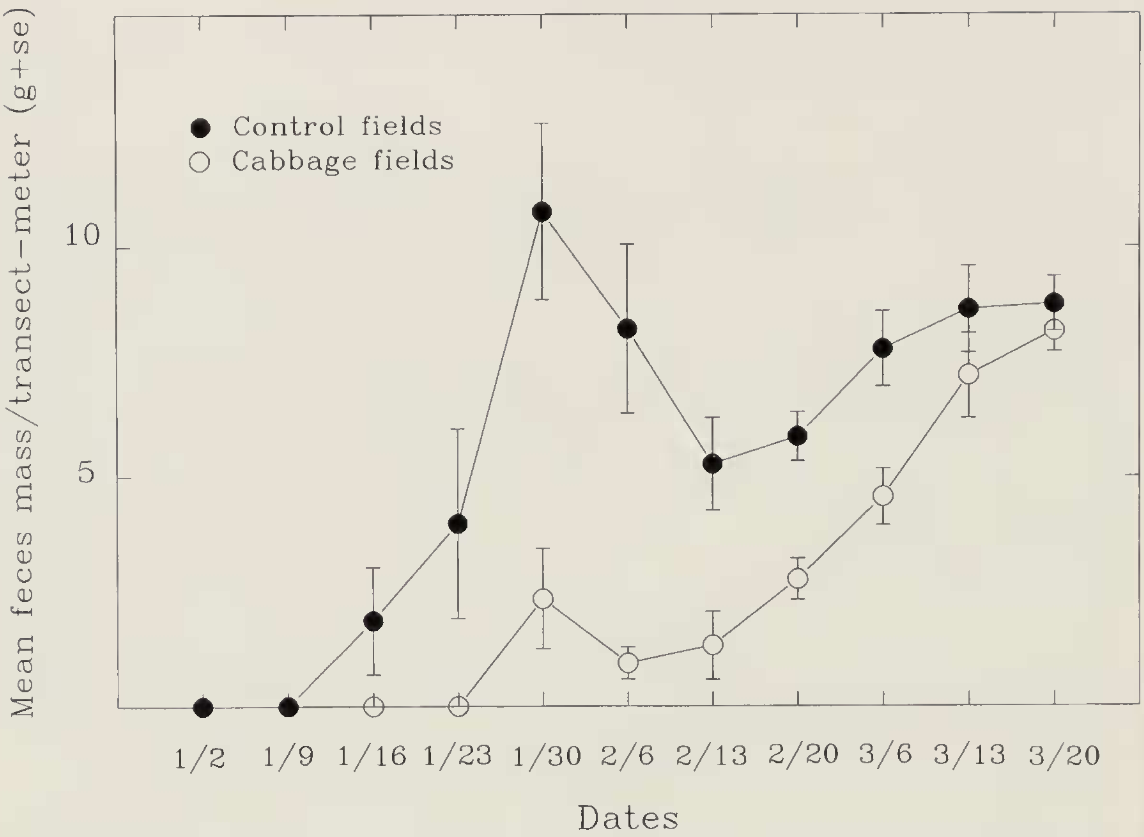

FIG. 1. Mean snow goose feces/transect meter in cabbage fields and control fields between January 2 1995 (week 1) and March 20, 1995 (week 11). Whiskers represent standard errors of the means.

We used a two-factor (sampling date, field type) repeated measures analysis of variance to evaluate the data. Subsequently, we used Tukey tests (Winer 1962:198) to isolate significant differences among means ($P < 0.05$).

Results.—No droppings were found in any field (cabbage or control) until the beginning of January. For that reason, only those data collected between 2 January 1995 and 20 March 1995 were evaluated. Overall, masses of droppings increased over time ($F = 18.3$; 10,40 df; $P < 0.0001$) and were greater in control fields than in cabbage fields ($F = 65.4$; 10,40 df; $P < 0.0002$). The significant interaction between time (dates) and field type ($F = 5.2$; 10,40 df; $P < 0.0002$) showed that differences of masses of droppings between cabbage and control fields decreased as the season progressed (Fig. 1). There were no significant differences by late March.

Discussion.—Snow Goose activity levels were significantly less in cabbage fields than in control fields. Although the data do not unambiguously address the issue of sulfur repellency, we believe that the activity difference is consistent with avoidance of the former and not preference for the latter. Sulfurous volatiles were readily apparent to us during our visits to cabbage fields throughout the study period. Similar odors were not detected in control fields. If sulfurous volatiles were important, then avoidance could reflect some characteristic of the cover crop (e.g., unpalatability acquired through the absorption and translocation of degradation products) or it could reflect an aversion to ambient (and readily detectable) volatiles in the field (Guildford et al. 1987). Regardless, our data are consistent with the notion that sulfurous volatiles may repel Snow Geese, at least within a feeding context. Perhaps sulfur containing substances could be developed as a method for goose grazing control. Many avian species have an acute sense of smell (Davis 1973, Clark and Mason 1989, Clark et al. 1993), with variability among species similar to that observed for mammals (Fazzalari 1978). While threshold data are unavailable, there is evidence that geese are highly responsive to odorous cues (Neuhaus 1963, Wurdinger 1979, 1982).

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J. RUSSELL MASON AND LARRY CLARK, *USDA/Animal and Plant Health Inspection Service, Animal Damage Control, Denver Wildlife Research Center, % Monell Chemical Senses Center, 3500 Market Street, Philadelphia, Pennsylvania 19104-3308.* *Received 25 May 1995, accepted 7 Nov. 1995.*